HABITAT SELECTION IN RESTORED GRASSLANDS: THE ROLE OF SOCIAL CUES IN THE SETTLEMENT OF GRASSHOPPER SPARROWS

BY

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THESIS

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ABSTRACT

Social cues are used by many species to locate and select breeding sites. The role of social information in attracting birds to newly restored habitats is management relevant, but largely unexplored. I investigated the effect of social cues in the settlement behavior of Grasshopper Sparrows (*Ammodramus savannarum*) in new habitats. I played conspecific vocalizations at newly created grasslands and compared settlement rates and breeding densities at those sites to control sites, without vocalizations. A subset of sites was monitored for two years with playbacks present in the first year, but not the second, to evaluate possible "carry over" attraction. The probability of newly restored grasslands being settled was similar in treatment and control sites; however, treatment sites had over twice the densities of Grasshopper Sparrows as control sites. Densities on the treatment sites remained high the following year without conspecific playbacks. Grasshopper Sparrows can locate breeding habitat without conspecifics, but the addition of social cues increases the number of individuals that settle at a site. Manipulation of social cues as a management tool has been useful in establishing populations previously extirpated and could be potentially useful in management of grassland species. For this reason, understanding how birds use social information when selecting a habitat can be valuable for conservation efforts.

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GENERAL INTRODUCTION

Over the last decade research has highlighted the importance of social information in habitat selection. Social information can range from the simple presence of conspecifics to their reproductive success (e.g. public information; Danchin et al., 2004). While habitat structure is extremely important in habitat selection (i.e., birds typically have specific habitats in which they breed), social information has also been shown to be highly influential in the selection process. My thesis investigated how the addition of social information (i.e. the presence of conspecific cues) to newly established grasslands affect Grasshopper Sparrows (*Ammodramus savannarum*) settlement.

Environmental Cues

The physical properties of a habitat such as floristic composition and vegetation structure are commonly studied when investigating habitat selection by birds (Cody, 1985). Many studies have investigated species-specific responses to vegetation structure and used these relationships to predict species' habitat preferences and distributions. MacArthur and MacArthur were among the first to do this by correctly predicting species distributions based on habitat variables such as plant species compositions, foliage height profiles, and latitude (MacArthur and MacArthur, 1961). For grassland species, the percentage of ground cover, stem density, and litter depth are common variables used to explain species-specific patterns of habitat selection (Fisher and Davis, 2010).

At a broader spatial scale, landscape variables such as patch size and juxtaposition to other habitats can all influence habitat selection (Ribic et al., 2009b). Some bird studies have suggested that species can be sensitive to patch size and will not settle in patches that do not meet some threshold size criteria (Fletcher, 2006). In landscapes with various habitats grassland birds prefer landscapes without forest habitats (Ribic et al., 2009a).

Though many studies have correlated bird density to vegetation or landscape features, other factors are clearly used to select habitat (Cody, 1981; Fletcher, 2006). Some birds cluster territories and often do not match predicted patterns of distribution based on available vegetation or landscape features (Tarof and Ratcliffe, 2004). Many grassland birds, for example, are known to have clumped distributions even in homogenous habitats (Cody, 1981; Moller, 1983; Green et al., 2002) . A potential explanation for this is that these birds are using social information when selecting a habitat (Cody, 1981; Stamps, 1988).

Social Information & Conspecific Attraction

Conspecific attraction is a term used to describe the use of the presence of conspecifics (a form of social information) as a cue for selecting habitat (Stamps, 1988). In colonial species, this behavior is well documented and has been used in a management context to attract birds to target locations (Kress, 1983). Re-establishment of formerly deserted breeding colonies via the use of conspecific vocalizations and decoys has been well documented in several colonial species (e.g., Atlantic Puffin (*Fratercula arctica*; Kress, 1983) and Dark-rumped Petrel (*Pterodroma phaeopygia*: Podolsky and Kress, 1992). Many non-colonial species also tend to aggregate territories in homogenous habitats (Moller, 1983), suggesting the use of social information for habitat selection. Conspecific attraction in response to playbacks has now been observed in a variety of territorial passerine species (Ward and Schlossberg, 2004; Ahlering et al., 2006; Hahn and Silverman, 2006, 2007; Nocera et al., 2006).

Classical models of density-dependent distributions and habitat selection (e.g. Ideal Free Distribution; Fretwell and Lucas, 1970, and ideal despotic distribution; Fretwell, 1972) are not consistent with distribution patterns of territorial species exhibiting conspecific attraction. These models of habitat selection hypothesize that animals will select the highest-quality habitat (Nocera et al., 2009); they assume strong density-dependent competition which would preclude using the presence of conspecifics to select habitats resulting in evenly-distributed distributions. Nocera et al. (2009) investigated several different habitat selection models and found that birds settled more in accordance with a "neighborhood model" of conspecific attraction, rather than models based on density dependence or resource availability. The neighborhood model suggests that birds aggregate into clusters in response to social information from conspecifics, rather than selecting the highest-quality habitat available. Settling in response to the presence of conspecifics results in aggregated territories suggesting the benefits of conspecific attraction outweigh the costs of density-dependent competition (Danchin et al., 2001). The hypothesized benefits of settling near conspecifics includes an increase chance of finding mates (Stamps, 2001; Danchin et al., 2004), gaining extra-pair copulations (Wagner, 1998), reduction of predation risk (Ahlering et al., 2010), and the potential to identify high-quality habitat (Stamps, 1988).

Applying Conspecific Attraction to Management and Conservation

Playbacks can quickly attract birds to previously unoccupied habitats (Ahlering and Faaborg, 2006; Betts et al., 2008). Because of the success of this method in attracting birds, playbacks could serve as a potential management tool for declining or endangered species (Schlossberg and Ward, 2004). Playbacks have been used to establish new colonies of endangered colonial seabirds (Kress, 1983) and endangered passerine species (Ward and Schlossberg, 2004). More research and cautious application are needed, as attracting birds to unused sites may have unforeseen consequences on fitness (Ahlering and Faaborg, 2006) or community dynamics (Danchin et al., 2004; Fletcher, 2007; Betts et al., 2010).

Understanding how birds select habitat is vital information for conservation and has important implications for management of declining species. Coupling research in social information and habitat use with restoration is a missing component of this research (Farrell et al., 2012). Simply knowing whether a target species does or does not use social information to influence habitat selection could improve success of restoration efforts to increasing grassland bird populations.

Habitat Restoration and Grassland Birds

Little natural grassland or prairie habitat remains in Illinois (Howe, 1994; Vickery and Herkert, 2001) and declines in these habitats are largely due to agricultural expansion (Johnson et al., 2011). Grassland birds are significantly affected by agricultural practices (Murphy, 2003) and are declining worldwide, as well as in Illinois (Herkert, 1994). Several grassland species have declined in the U.S. by between 25-60% since the 1960s (Herkert, 1995). The Farm Bill, administered by the United States Department of Agriculture (USDA), provides subsidy and conservation programs to farmers and, through these programs, is restoring grassland habitat.

The Conservation Reserve Program (CRP) is a large program under the Farm Bill predominantly responsible for converting agricultural land to grassland or wetland habitats in the

United States. Traditionally, the goal of these programs was to prevent soil erosion and buffer nutrient runoff into waterways and wildlife conservation was a secondary goal (Johnson and Igl, 1995). A new program called State Acres For Wildlife Enhancement (SAFE) is a version of CRP and provides high-quality habitat specifically for grassland wildlife. SAFE is a national program with most enrollments concentrated in the Midwest or Great Plains regions of the United States (USDA, 2008). To date, there are 657,326 ha of land enrolled in the SAFE program nationwide, with 11,458 ha in Illinois as of spring 2012 (Graves, personal communication). In Illinois, SAFE is concentrated within 31 focal areas split between two general regions of the state; the Grand Prairie Natural region (northern half) and the Southern Till Plain Region (southern half; Fig. 1). Focal areas within these regions were selected based on wildlife conservation need, amount of erodible land, and amount of surrounding grassland habitats. New grasslands enrolled in the SAFE program were used for my research.

Study Significance

Diverse sources of information are available to birds when locating and selecting breeding habitat (Danchin et al., 2001). With a growing body of evidence in support of social information being used for habitat selection, coupling research in social information and habitat cues with restoration is a logical next step. Previous studies have shown that some grassland birds will settle preferentially near conspecifics in response to playbacks (Ahlering et al., 2006; Nocera et al., 2006; Virzi et al., 2012), but few have specifically investigated social cue use in newly created habitats. Virzi et al., (2012) conducted playback experiments on a grassland resident species, the Sable Cape Seaside Sparrow (*Ammodramus maritimus mirabilis)* in a large scale restoration project in the Florida Everglades. Playback methods proved to be a viable method for increasing populations in this endangered sub-species. The same may be true for declining migrant grassland species like the Grasshopper Sparrow (*Ammodramus savannarum*) and my study investigated playbacks effectiveness in attracting individuals to new habitats. Grassland habitats tend to experience high disturbance rates and quick succession with many species restricted to a particular successional window in which habitat is appropriate. Using new habitats provides an opportunity to investigate the relative importance of social cues in the colonization process, especially for early successional species like the Grasshopper Sparrow. Understanding habitat selection in relation to restored grasslands and social information use can be potentially useful. How managers configure grasslands, how and when they implement management practices (e.g. mowing, burning) and how managers plan for species-specific conservation rely heavily on what is known about habitat selection. Information on the source and use of social information in new habitats and through time is potentially valuable in influencing how conservation and management efforts are planned and executed (Swaisgood, 2007). The results of my research will not only aid conservation efforts, but also add to what is known about the use of social information by grassland birds.

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INTRODUCTION

The presence of conspecifics can provide useful social information for birds selecting habitat (Danchin et al., 2004; Ward and Schlossberg, 2004). Social information is defined as information extracted from the observation of other organisms, either conspecifics or heterospecifics (Wagner and Danchin, 2010). In birds, a singing male can provide social information that signifies the presence of appropriate habitat (Stamps, 1988). The presence of conspecifics can not only provide cues for finding habitat, but may also communicate the quality of habitat for breeding. Selecting habitat based on the presence of conspecifics can provide potential benefits such as increased mating success, protection from predators, and overall improvement of an individual's reproductive success relative to unoccupied locations (Stamps, 1988; Ahlering et al., 2010).

The information gained from conspecifics being present at a specific site can be hierarchical in nature. For example, the presence of conspecifics can be used to simply find a breeding location (Stamps, 1988), but if finding an appropriate breeding location is not a challenge (appropriate habitat is plentiful) the density or behavior of conspecifics may provide information that can be used to evaluate appropriate habitat (Farell et al., 2012). In many species, individuals exhibit a win-stay loss-shift strategy (Switzer, 1993). That is, if an individual is reproductively successful they return to the same breeding location in the subsequent year, but if unsuccessful they disperse elsewhere. Also, individuals returning to the same breeding site often return earlier in the breeding season than individuals dispersing to new locations (Moller et al., 2004). Therefore, the presence of territorial conspecifics may indicate that birds bred at the site the previous year and where reproductively successful at the site. While the presence of conspecifics may ultimately attract individuals to a breeding location the reason why those individuals used the presence of conspecifics to settle at the site may differ.

Social information may be acted upon immediately or at some point in the future (Stamps 2001, Danchin 2001, Danchin et al. 2004). Using social cues years after assessment has sometimes been termed “carry-over attraction” and several studies have investigated this behavior (Doligez et al., 2004; Ward 2005; Betts et al., 2008). The relationship between time and the quality of information is likely different in different habitats. In habitats where the quality varies between years, the quality of information is assumed to decline as time since assessment increases (Fletcher & Sieving, 2010). Therefore, a relatively high-quality site as determined by social information may no longer be high-quality the following year.

Research into how territorial species use social cues when selecting a habitat has grown in the last decade (e.g., Ahlering et al., 2010) and a handful of studies have investigated how grassland birds use social information to select breeding sites (e.g., Ahlering et al., 2006; Nocera et al., 2006; Harrison et al., 2009; Vogel et al., 2011; Virzi et al., 2012). Studies of grassland birds have shown that individuals will settle where artificial social cues (i.e. conspecific vocalizations) are introduced. Baird’s Sparrows (*Ammodramus bairdii;* Ahlering et al., 2006) and Henslow’s Sparrows (*Ammodramus henslowii;* Vogel et al., 2011) responded to conspecific vocalization given early in the breeding season by setting up territories around playbacks (speakers broadcasting conspecific vocalizations). Nocera et al, (2006) broadcasted post-breeding cues (later half of breeding season) and found that Bobolinks (*Dolichonyx oryzivorus*) responded strongly while Nelson’s sharp-tailed Sparrow (*Ammodramus nelsoni*) did not. Grasslands are ephemeral and dynamic ecosystems with short windows of suitability over time for constituent bird species (Herkert, 1998), therefore it is likely that social information will be most valuable upon assessment of the information. Male grassland birds, like many suites of species, sing prominently and loudly to defend their territory, therefore providing social information. Unlike many suites of species many grassland birds also sing frequently at night, providing a nearly constant stream of information at conspecifics could use to locate or evaluate breeding locations.

Understanding habitat selection process of grassland birds is particularly important because the primary conservation strategy for this suite of species is to create addition habitat (Herkert 2009; Igl and Johnson, 1997; Johnson and Igl, 1995). The assumption being if you build the habitat the birds will follow (Ahlering and Faaborg, 2006). In the United States and Europe, grassland set-aside programs can rapidly restore grassland habitat and these programs are relatively common (66 million hectares of grasslands are currently in place due to set-aside programs in the United States; Baylis et al., 2008). All studies to date on the use of social information by grassland birds, however, have been conducted in established grasslands. Using established grasslands can be potentially problematic. Did added social cues "seed" individuals to colonize a previously known patch or did social cues attract birds to patches previously unknown to that individual? Newly created grasslands lack social information potentially resulting in the site being slow to be colonized. These newly created grasslands also provide a unique opportunity to investigate the role of social information in the colonization of habitat, without the confounding effect of previous knowledge of the site by the individuals (all new grasslands had been corn or soy bean field for at least five years and likely decades.).

I played conspecific vocalizations to investigate the effect of social information on colonization and breeding densities of Grasshopper Sparrows (*Ammodramus savannarum)* on newly restored grassland sites. Grasshopper Sparrows are a declining species (Herkert, 1995), and the target of set-aside programs and habitat restoration. Grasshopper Sparrows prefer early successional habitats making them a good candidate as Farm Bill and other programs often create new high quality habitat from rowcrops. I therefore predicted that, by adding conspecific vocalizations to new grasslands, the probability of colonization and the densities at treatment sites (i.e. vocalizations added) would be greater than those at controls (newly created habitats without vocalizations). I also expect that Grasshopper Sparrows will use social information upon assessment and there will be little carry-over effect; in year 2, sites that were previous treatment site, but in year 2 did not have playbacks would have similar densities as control sites. I discuss the role of social cues in habitat selection, the timing of assessment and use of social cues, and how understanding habitat selection behavior of grassland birds can benefit conservation programs.

METHODS

Study Species

Grasshopper Sparrows are monogamous and breed throughout their breeding season (May - July; Vickery 1996) preferring early successional habitat with a mix of bare ground and litter cover for foraging substrate (Whitmore, 1981). Regular fire disturbances, in intervals of 2-3 years, are used to maintain Grasshopper Sparrow habitat in Illinois (Herkert, 1998). They are migratory, with a widely distributed breeding range across North America. Grasshopper Sparrows are listed as a species of concern in Illinois with a > 60% decline in population since the 1960's (Herkert 1995).

Study Areas

In the United States, the Department of Agriculture's set-aside programs provide incentives for landowners to replace row crop agriculture with grasslands and are designed to reduce soil erosion, buffer wetlands from nutrient run-off, and provide wildlife habitat (Johnson and Igl, 1995). This study was conducted in central Illinois within an intensive agricultural landscape. Study sites were located in four sampling regions in Illinois, consisted of newly planted set-aside grasslands enrolled in the SAFE program, a version of USDA's Conservation Reserve Program (CRP). SAFE is specifically intended to provide habitat for grassland wildlife (Fig. 1). All newly created grassland sites had either been corn or soybeans (the regions' dominant cover-types) in the previous year. Sizes of field sites ranged between 2.5 to 30ha. All new grasslands were planted with cool season grass mixes. Dominant plant species observed includes smooth brome (*Bromus inermis*), foxtail (*Hordeum murinum*), giant foxtail (*Setaria faberi*), Canada wild rye (*Elymus canadensis*), alfalfa (*Medicago sativa*), big bluestem (*Andropogon gerardii*), and partridge pea (*Chamaechrista fasciculata*).

Field Experiment

I used 32 newly established grasslands that were $\geq$1 km apart. I surveyed all birds seen or heard on 12 new sites in 2010 and 20 new sites in 2011. Each year, I randomly selected half of the sites to receive playback or control treatments. In 2011, I revisited the 12 sites used in 2010, but did not broadcast playbacks during that second year to investigate whether social cues are used from one year in habitat decisions in a following year.

At treatment sites, I used playbacks from commercially available male Grasshopper Sparrow vocalizations recorded in Indiana (Elliott et al. 2010). Playback tracks were constructed using the program Audacity (Audacity ® Version 1.2.6, http://audacity.sourceforge.net).

Playbacks consisted of primary and secondary songs and chip notes randomly interspersed with quiet periods to avoid habituation and simulate territorial behavior (Ward and Schlossberg 2004). I broadcasted songs using FoxPro game callers (FOXPRO Inc., Lewiston, PA) powered by 12v deep-cycle batteries. Playback tracks were audible at >500m from speakers. Beginning in mid-April, I broadcasted vocalizations in the evening (~16:00 – 18:30), night (~20:30 – 05:00), and morning (~07:00 – 09:30) hours to replicate natural vocal activity and to provide cues for nocturnal migrants. No songs were played for 30 minutes between sequential intervals of broadcasting and no songs were played for an hour before or after sunset and sunrise. I broadcasted songs throughout the breeding season to provide post-breeding social information for prospecting individuals at the end of the breeding season (~July).

The design of my playback system followed the design of Ward & Schlossberg (2004) with modifications similar to what was used in Vogel et al., (2011). FoxPro callers were connected to a digital timer and a 12v deep cycle battery. Then, these were placed in a Rubbermaid waterproof container with holes cut in both sides to allow for sound to be audible to birds. Mesh was then placed over the holes to prevent debris or insects from entering systems. Lastly, the playback system was elevated on a cinderblock to place speakers above or at even level with surrounding grass for better broadcast and to simulate a more preferable perching height for Grasshopper Sparrows singing.

Estimation of Grasshopper Sparrow Occupancy and Density

Grasshopper Sparrows arrive on the breeding grounds during the last week in April or first week in May in Illinois (Vickery 1996). I conducted, 10-minute, unlimited-radius point counts weekly in each field from early May through the end of July (Bibby et al. 2000). Counts were conducted from sunrise up to 10:00am and all birds heard and seen were recorded. No counts were conducted in high winds, rain, or other inclement weather.

If Grasshopper Sparrows were detected at a site on at least one occurrence, I classified the site as "occupied." Occupancy was simply the percentage of sites (treatment or controls) where at least one sparrow was detected. Densities at each occupied site were estimated from point count data and modeled using program Distance 6.0 v.2 (Thomas et al. 2010). The best fit model for my data was a half-normal distribution model with cosine series adjustments.

Characterization of Habitat Structure

To assess if there were any confounding vegetation structure or diversity differences between treatment and control sites, I measured ground cover (bare, litter, grass and forb), litter depth, and average height and density of vegetation. I sampled vegetation during the last two weeks in June in both years along line transects in all experimental sites. A 250m line was traversed in a random direction through fields and five transects of 25m were randomly dropped every 50m perpendicular to the main line. I then took measurements at 5m intervals. My measurements were collected using a 50x50cm quadrat frame and Robel pole for vertical density sampling (Daubenmire 1959, Robel et al. 1970).

Statistical Analysis

Year 1 Treatment Effects: I used a Fisher's exact test to assess if the proportions of sites occupied or unoccupied differed between controls and treatments to look at probability of playbacks producing more individuals in treatment sites. To compare estimates of breeding densities between treatments and controls, I used a 2-way ANCOVA with treatment and year as main factors. Covariates included with main factors included field size and habitat characteristics (see below for habitat). All main effect interactions were non-significant and dropped from further analysis.

Changes in density over time: To assess changes in densities within a breeding season, I used a repeated measure ANOVA. With visit as the within subjects factor and treatment as the between subjects factor, sites were visited for 10 consecutive weeks throughout each season. For within season change in density (as estimate by DISTANCE) over time, I compared treatment and control densities for a single season. Using this method will tell me whether any significant increase is occurring over a single breeding season.

I analyzed a subset of sites for which I have two years of data for treatment and control densities. Recall, 12 sites were used in 2010 with playbacks present and then surveyed again with no playbacks present in 2011. I took these data and ran repeated measures ANOVA to determine if densities changed over the two years for treatment and controls. I did this by comparing treatment densities from year 1 to densities from year 2. I then compared treatment and control densities for the two years. Any difference between year 1 and year 2 in treatment site densities, along with significant increases over time, would suggest carry-over attraction as a result of playback applications.

Habitat Structure: I used principal component analysis (PCA) to reduce the dimensionality of the habitat data. Six principle components were derived, but only two were retained (accounting for $\approx$66% of the total sample variance) to compare overall habitat structure of the treatment and control sites.

RESULTS

Only seven (4 treatment, 3 control sites) of the 32 sites were not settled by Grasshopper Sparrows. Grasshopper Sparrows were not more likely to settle at treatment sites than control sites (G_{adj} = 0.16, DF=1, p=0.70; Fig. 2). Grasshopper Sparrows began settling at both treatment and control sites within a week of playbacks being deployed. Eight sites (25% of all sites) were settled in the first week (the week playbacks were initiated and the birds arrived) and by the third week 20 of the 32 sites (63%) were settled, there was no difference in how quickly treatment and control sites were settled (Fig. 3).

The mean density of birds on treatment sites (2.03 ± 0.64 birds per ha) was greater than control sites (1.08 ± 0.26 birds per ha; $F_{1, 23}$=6.48, p=0.02; Fig. 4). Across the first breeding season at the newly created grasslands Grasshopper Sparrow density steadily increased at treatment sites. The density of sparrows was less than 0.5 birds/ha at treatment and control sties during the first week of the breeding season, however starting the second week densities doubled in treatment sites and continued to increase throughout the season ($F_{9, 90}$=5.56, p<0.01), whereas there was no significant increase in density at control sites throughout the breeding season ($F_{9, 108}$=1.71, p=0.10; Fig. 4).

Twelve sites were monitored for two consecutive years to investigate if the addition of social information in one year leads to increased settlement and density in year 2 (in year 2 there were no playbacks). If the addition of social information (conspecific vocalizations) resulted in a carry-over effect I expected the percentage of sites occupied and the density at treatment sites to be greater than that of control sites. There was no difference in the percentage of sites occupied (G_{adj} = 0.05, DF=1, p=0.83; Fig. 2) or the densities between treatment and control sites in year 2 ($F_{1, 10}$=0.06, p=0.811, N=12, Fig. 4). Densities at treatment sites in the second year were not different than densities observed in the previous year ($F_{8,32}$=0.73, p=0.70); however, control site densities in year 2 were greater than in year 1 ($F_{1,111}$=4.50, p=0.04; Fig. 4). While there was no carry-over effect of playing conspecific vocalizations, the density of sparrows at both treatment and control sites was much greater at the beginning of the season in year 2 as compared to year 1 (Fig. 4).

DISCUSSION

Grasshopper Sparrows use both the presence of appropriate habitat and social information to select breeding locations. Grasshopper Sparrows are known to be a “pioneer species” (Vickery, 1996); among the first species to colonize new grasslands ((Whitmore, 1981; Igl and Johnson, 1995). Being a pioneering species, individuals must use non-social information to select these new habitats. Likely due to the use of non-social information, I found that Grasshopper Sparrows were equally likely to settle at treatment as at control sites. Individuals found these newly created sites very rapidly and within a couple weeks over half of the sites were settled, with the addition of social information making no difference in whether or not the site was settled.

While social information did not affect the probability of locating and settling a site, treatments sites attracted twice as many sparrows as control sites. Though there is no difference in the number of sites settled between treatment and control sites, the density is much greater at treatment site. Grasshopper Sparrows appear to not be using the presence of conspecifics not to locate grasslands, but rather to evaluate their quality of habitat and select habitats later in the breeding season.

The reason why social information did not affect initial settlement, but did affect overall density may be due to the use of social information differently throughout the breeding season. Unlike other species, Grasshopper Sparrows have very low site fidelity (Jones et al., 2007). Given this low site fidelity, only a few individuals likely use a win-stay loss-shift strategy. If individuals do not use this strategy then the presence of conspecifics at a site early in the breeding season simply provides a cue on the location of appropriate habitat not the quality of that habitat. As Grasshopper Sparrows are a “pioneering species” it would be expected that they would be very good at locating sites without the need for social information. Early in the season, social information provides little information on the quality of the site.

Ground nesting birds such as Grasshopper Sparrows have high levels of nest failure due to predation (Vickery, 1996). The increase in density at treatment sites throughout the breeding season is likely not due to birds arriving to breed for the first time that year, but rather individuals either renesting after a nest failure or attempting a second brood. Grasshopper Sparrows whose nests fail often move to new locations to breed (Wiens, 1973; Vickery, 1996; Dechant et al., 1998). The presence of singing males later in the breeding season may suggest they had been successful in their first brood, their young had fledged, and the male was advertising for a female for a second nest. Conversely control sites attracted individual early in the year when sparrows were likely using vegetation-based cue to select a site, and while I did not monitor nesting success it is likely that some nests were successful, but many failed. The individuals of failed nests may prospect to other locations to assess their relative quality (Ward, 2005) and if there were many singing males it may suggest a higher-quality location (Farrell et al., 2012).

Because both treatment and control sites were settling I could not evaluate carryover effects by comparing treatments and control sites. However Fig. 3 illustrates how the density of birds at both treatment and control sites in year 2 started off much greater than in year 1, suggesting individuals already knew about these sites and quickly settled them. Rapid settlement of these 2-year old sites following playbacks suggests that either site fidelity in the species is higher than previously found (other studies have found very low site fidelity; Jones et al., 2007) or birds had located the site the previous year and used this information to quickly locate and settle sites.

Applying Behavior to Management & Conservation

Traditionally, habitat management focused on providing appropriate vegetation structure and composition (i.e., habitat; Cody, 1985) with the idea that simply creating habitat will attract target species (Ahlering & Faaborg, 2006). My results and those of other researchers (Ahlering et al., 2006; Harrison et al., 2009; Vogel et al., 2011) show that social information can be an important part of the habitat selection process. With control sites being settled by Grasshopper Sparrows, the only cue likely to have been used were vegetation structure and composition. The rapid settlement of newly created sites bodes well for the strategy of simply creating habitat and waiting for individuals to locate the site. Several studies have found that programs such as the Conservation Reserve Program are effective measures to maintain or increase grassland bird populations (Igle and Johnson, 1995; Herkert, 1998; Fletcher and Koford, 2002).

While social information does not need to be artificially added to newly created grassland sites to illicit settlement, understanding the habitat selection process of Grasshopper Sparrows can provide valuable insights into management. Grasshopper Sparrows appear to use social information later in the breeding season to select locations in which to renest or attempt a second brood. In order to use social information later in the breeding season, individuals have to move around the landscape prospecting at potential sites. If sites are widely scattered individuals may not be able to effectively collect information with which to make an informed decision or they may spend significant amounts of energy and time searching for and assessing far flung locations. Currently, the creation of grasslands via set aside programs operate on a first-come first-serve basis for farmers, therefore grasslands are often randomly located throughout a political entity such as a U.S. state. Because of this appropriate habitat can often be isolated and small patches surrounded by agriculture. If a Grasshopper Sparrows strategy is to use vegetation-based cues to quickly select a breeding location early in the year and then move between locations assessing their quality via social information, set aside programs whose goal is grassland bird conservation may be better served focusing grassland creation in specific areas. By focusing grassland creation in a region rather than randomly scattering grasslands, birds may more readily assess a wider variety of locations. Having more patches together may provide them the information with which to make more informed choices and potentially select higher-quality sites and ultimately experience greater reproductive success. Experiments on the landscape configuration, proportion of grassland available and proximity of patches should be undertaken in concert with social cues. Understanding the affect social cues and landscape have on habitat selection for Grasshopper Sparrows and other grassland specialists will be useful information for large scale conservation planning.

SUMMARY

The landscape of Illinois is highly fragmented and dominated by agriculture. It is important for restoration efforts, such as the SAFE program, to be strategically implemented to benefit wildlife. Grassland species are declining worldwide and adding new habitat is necessary for conservation of these species (Igle and Johnson, 1999). My research suggests that Grasshopper Sparrows settle new set-aside habitats equally regardless of the presence of social information. When social information is added, however, densities increased dramatically and were twice as high as those observed in control sites (i.e. no added social information). Additionally, responses to social cues occur continually throughout the breeding season. Social cues added in one year do not appear to produce carry-over attraction. While densities were high at the start of the second season, it is unclear whether this is just from new individuals in the population discovering patches or returning individuals from the previous year influenced by playbacks.

The SAFE program creates new habitats quickly and since 2008 has added more than 11,000ha in Illinois. Traditionally, conservation in grasslands has focused on creating new habitat and waiting for birds to find them. Often, these sites go unused and may be lacking needed characteristics needed for settlement. Using playback methods to encourage settlement of grassland birds in new sites is an enticing management tool. My research shows that this method may increase densities of Grasshopper Sparrows in new grassland habitats, but is not necessarily needed to facilitate settlement. Given the variability in grassland habitats and the short successional windows Grasshopper Sparrows have to use new habitats, accelerating colonization via playbacks could enhance Grasshopper Sparrow populations. Grassland birds often show clustered distributions (Wiens, 1973) potentially due to social cues. Therefore, a strategy of clustering grasslands across the landscape, coupled with playbacks, could benefit declining species.

Future research into social cues and restoration is needed. Long term monitoring through multiple breeding seasons would be useful to evaluate how social cues affect habitat selection over time (Ahlering et al., 2010), and how this interplays with population dynamics. Extending these questions to investigate landscape configuration, proportion of grassland available, proximity of patches and how all these affect social information use is valuable to conservation planning.

TABLES & FIGURES

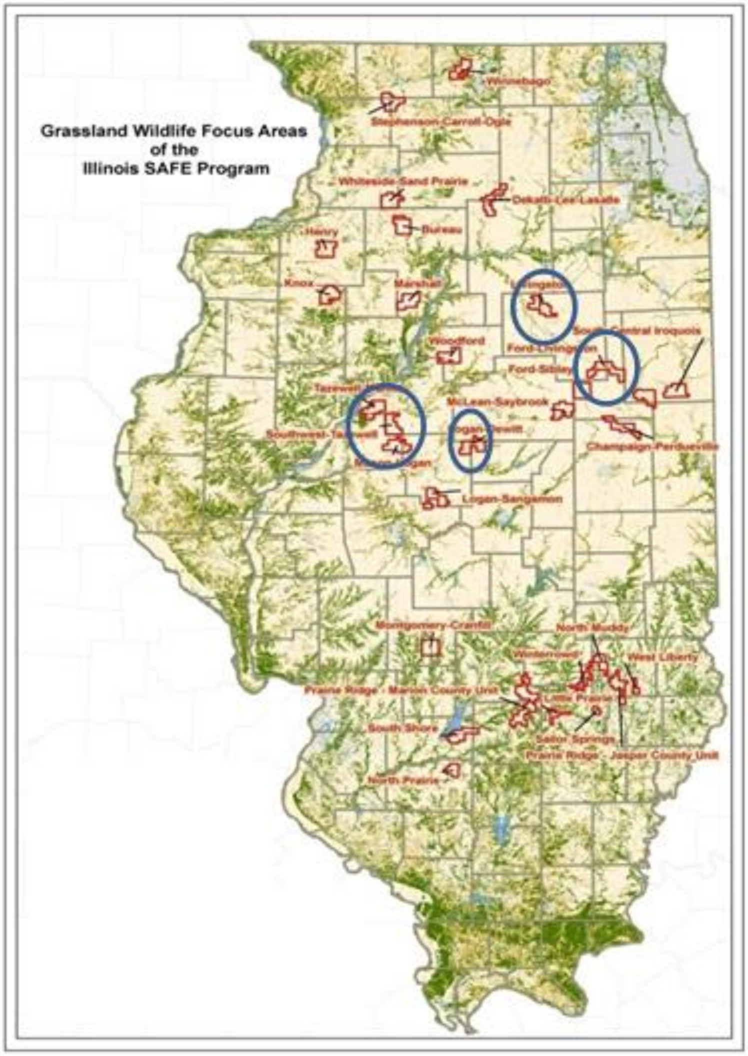

Figure 1: Map indicating general locations of field sites for 2010-2011 playback experiments. Red polygons represent areas in Illinois where landowners can enroll in SAFE programs. Circles represent areas used for field sites in this study.

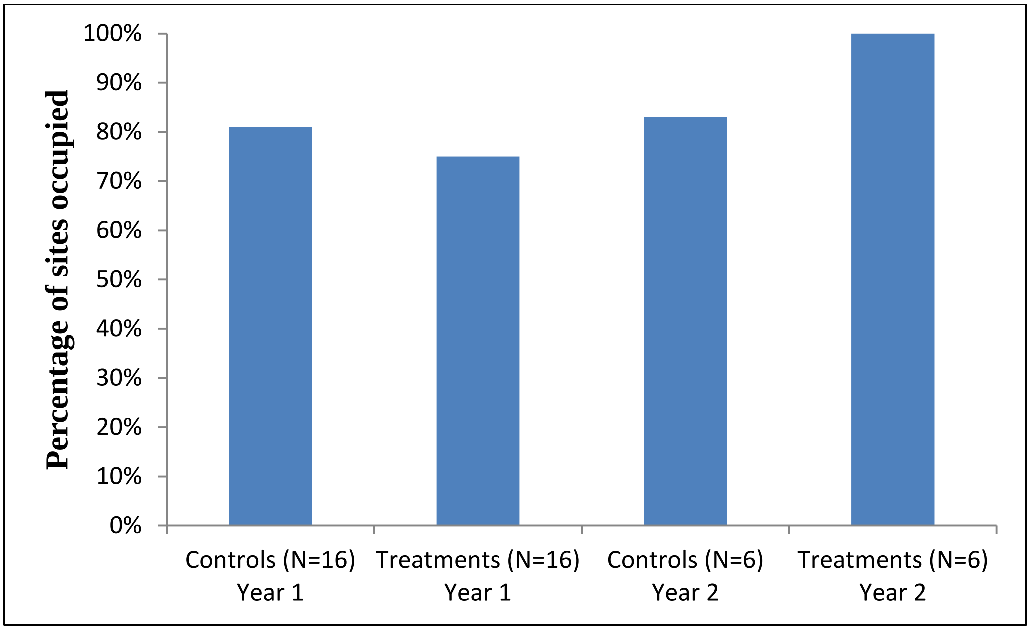

Figure 2: The proportion of sites with at least one Grasshopper Sparrow detected in year 1 and year 2 of monitoring.

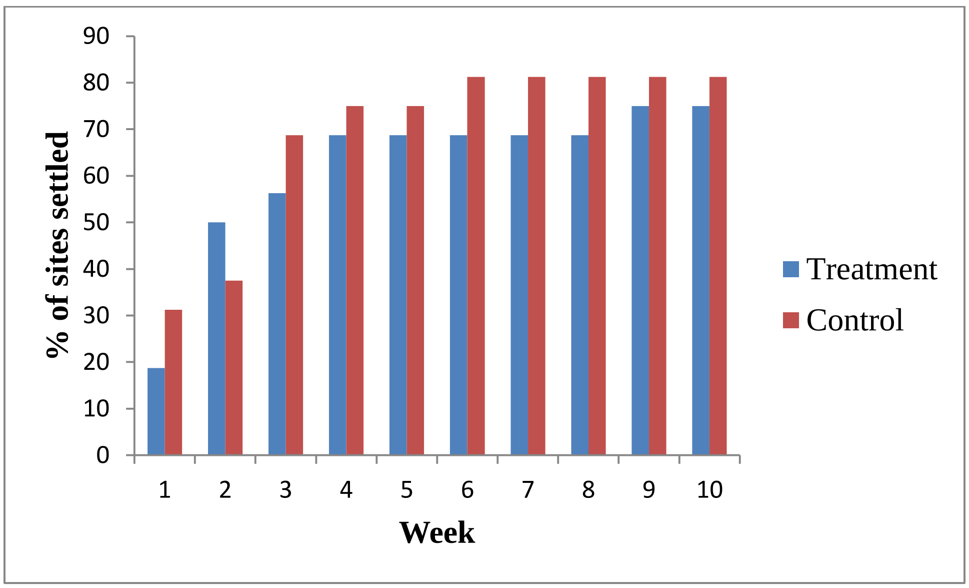

Figure 3. Percentage of sites settled (at least one sparrow present) over the course of the 10 week study for sites in first year of planting.

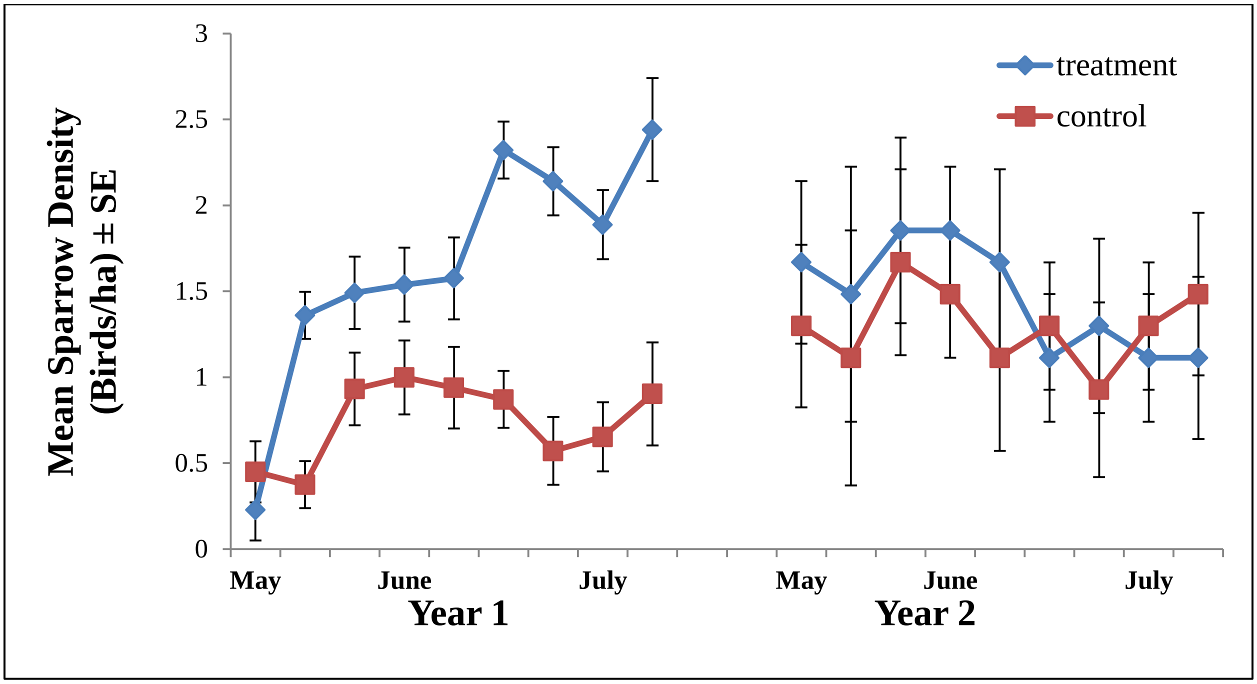

Figure 4: Mean density of Grasshopper Sparrows over time. Year 1 consists of data from 32 newly planted grasslands converted from rowcrop. Year 2 consists of mean densities from monitoring 12 the year following conversion. No playback treatments were administered in the second year of monitoring. Bars represent ± SE.

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APPENDIX A: Density and Occupancy Data by Site

Table A.1: Mean density estimates for each site in first year of playback experiments ± SE and 95% confidence intervals for densities. Estimates were generated using Distance 6.0. All sites were independent and separated by $\geq$1km. Dashes indicate sites that were never occupied by Grasshopper Sparrows.

						95% CI	
Site	**Treatment**	**Density**	**± SE**	**Occupancy**	**± SE**	**Lower**	**Upper**
PB1	Control	0.96	0.23	0.50	0.17	0.60	1.53
PB2	Treatment	-	-	-	-	-	-
PB3	Treatment	4.09	1.05	0.80	0.13	2.48	6.75
PB4	Control	0.80	0.20	0.40	0.16	0.50	1.30
PB5	Control	0.96	0.26	0.40	0.16	0.56	1.64
PB6	Treatment	5.34	1.23	0.90	0.10	3.40	8.37
PB7	Control	-	-	-	-	-	-
PB8	Treatment	-	-	-	-	-	-
PB9	Treatment	4.64	1.11	0.90	0.10	2.91	7.40
PB10	Control	2.31	0.57	0.70	0.15	1.43	3.74
PB11	Control	2.62	0.65	0.70	0.15	1.62	4.25
PB12	Treatment	1.76	0.44	0.60	0.16	1.08	2.87
Q1	Treatment	1.01	0.18	0.40	0.16	0.68	1.51
Q2	Control	1.51	0.11	0.80	0.13	1.32	1.74
Q3	Treatment	-	-	-	-	-	-
Q4	Treatment	2.27	0.27	0.90	0.10	1.77	2.91
Q5	Control	-	-	-	-	-	-
Q6	Control	-	-	-	-	-	-
Q7	Treatment	-	-	-	-	-	-
Q8	Treatment	0.13	0.02	-	-	0.96	0.17
Q9	Control	1.26	0.22	0.70	0.15	0.86	1.85
Q10	Control	1.13	0.24	0.40	0.16	0.68	1.88
Q11	Treatment	1.13	0.26	0.40	0.16	0.68	1.90
Q12	Treatment	2.65	0.33	0.80	0.13	2.03	3.46
Q13	Treatment	2.65	0.31	0.80	0.13	2.07	3.38
Q14	Control	0.63	0.05	0.50	0.17	0.53	0.75
Q15	Treatment	0.85	0.09	0.50	0.17	0.68	1.06
Q16	Control	0.76	0.08	0.50	0.17	0.61	0.94
Q17	Control	1.77	0.14	0.90	0.10	1.52	2.05
Q18	Control	1.01	0.07	0.80	0.13	0.88	1.15
Q19	Treatment	3.03	0.26	0.80	0.13	2.55	3.59
Q20	Control	0.13	0.02	0.10	0.10	0.10	0.17

Table A.2: Mean density estimates per site the year following addition of playbacks (year 2) including standard error and 95% confidence intervals. Estimates were produced using Distance 6.0. Only PB sites were monitored for 2 years. These estimates were gathered in 2011 while Q sites (See above) were newly planted and receiving playback treatments. Periods indicate sites that were never occupied by Grasshopper Sparrows.

Site	Trt	Density	± SE	Occupancy	± SE
PB1	Control	0.84	0.11	0.56	0.18
PB2	Treatment	-	-	-	-
PB3	Treatment	2.87	0.27	1.00	0.00
PB4	Control	0.36	0.07	0.22	0.15
PB5	Control	1.88	0.19	0.78	0.15
PB6	Treatment	1.44	0.22	0.67	0.17
PB7	Control	-	-	-	-
PB8	Treatment	-	-	-	-
PB9	Treatment	3.23	0.32	1.00	0.00
PB10	Control	1.68	0.15	1.00	0.00
PB11	Control	2.99	0.27	1.00	0.00
PB12	Treatment	0.12	0.02	0.11	0.11

APPENDIX B: Data summaries and Supplemental Figures

Table B.1: Mean values for vegetation data. All data was collected in mid-June of each year at peak of growing season. PB sites were used in 2010 and Q sites were used in 2011.

Site	Treatment	bare	grass	forbs	litter	other	Mean Litter depth (cm)	Mean Vegetation Height (cm)	Mean Density (dm)
PB 1	Control	32.80	18.40	40.80	8.00	-	0.81	40.11	5.77
PB 2	Treatment	32.60	2.80	14.40	50.20	-	2.52	23.10	1.24
PB 3	Treatment	31.60	7.00	38.40	22.00	3.00	1.78	190.16	2.38
PB 4	Control	43.00	26.80	25.20	5.00	-	0.11	34.27	4.28
PB 5	Control	92.20	4.20	-	3.60	-	0.14	3.79	0.04
PB 6	Treatment	3.60	82.40	11.20	2.80	-	0.51	22.62	2.32
PB 7	Control	8.40	1.80	12.80	77.00	-	3.92	17.96	1.32
PB 8	Treatment	31.60	6.60	16.60	44.80	0.40	2.42	23.35	1.21
PB 9	Treatment	40.20	26.40	23.80	8.40	1.20	0.60	28.75	4.21
PB 10	Control	41.60	16.80	19.80	21.80	-	1.89	26.70	2.46
PB 11	Control	40.60	6.20	4.20	49.00	-	2.07	12.32	0.63
PB 12	Treatment	31.60	44.80	23.60	0.00	-	0.00	48.36	6.25
Q1	Treatment	13.00	1.20	18.40	67.40	-	1.40	16.54	1.41
Q2	Control	17.20	-	23.80	59.00	-	1.56	15.09	1.36
Q3	Treatment	60.80	1.00	11.60	27.00	-	2.06	8.40	0.41
Q4	Treatment	51.20	34.00	7.40	7.80	-	0.42	43.06	5.78
Q5	Control	27.50	57.00	7.50	8.00	-	1.14	43.13	5.58
Q6	Control	27.00	40.80	6.80	21.80	3.60	2.38	21.59	2.13
Q7	Treatment	56.40	32.00	5.40	6.20	-	1.57	21.66	1.43
Q8	Treatment	21.00	61.00	17.00	-	1.00	0.00	74.05	8.81
Q9	Treatment	22.60	49.60	17.80	10.00	-	1.04	24.63	2.18
Q10	Control	30.60	-	60.80	8.80	-	0.55	43.30	5.90
Q11	Treatment	50.00	25.80	14.20	10.00	-	1.05	26.14	2.11
Q12	Treatment	58.00	9.20	17.20	15.60	-	1.09	12.21	1.20
Q13	Treatment	13.40	51.20	30.80	3.00	1.60	0.57	34.32	3.92
Q15	Treatment	4.40	45.00	12.20	38.40	-	4.47	42.83	5.20
Q19	Treatment	0.20	21.00	19.20	59.60	-	3.36	28.98	3.32
Q20	Control	8.00	26.60	63.40	1.00	1.00	0.14	36.75	4.31

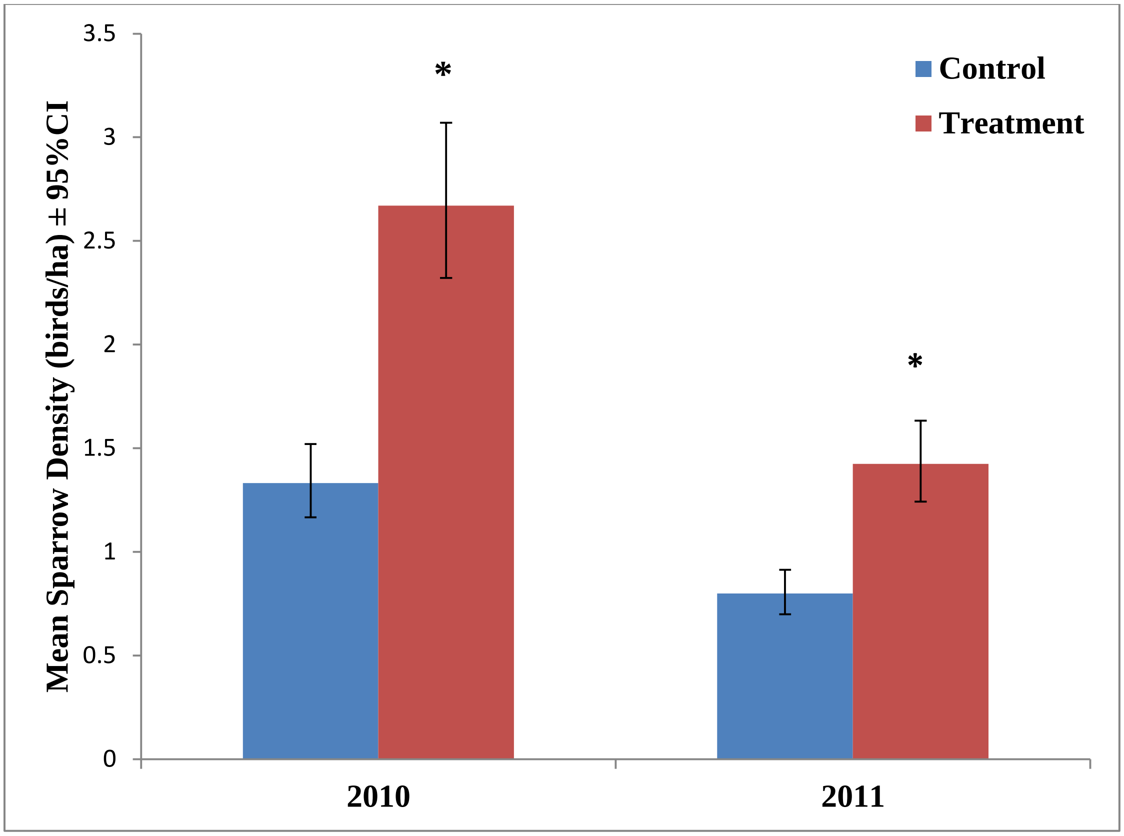

Figure B.1: Mean density for treatment and control sites for 2010 and 2011. Asterisk signifies significant differences between treatment and control sites for each year.